

Plant functional groups for carbon and nitrogen cycle modelling and diversity estimation in boreal forest ecosystems

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Description: The Institute of Mathematical Problems of Biology of RAS (IMPB RAS) was founded in 1972. The main areas of investigations are mathematical modeling of biological objects and phenomena, development and application of mathematical methods in biological research, bioinformatics. Laboratory of Computational Ecology conducts research work in field of biodiversity in the following topics: • Databases in geobotany and forest ecology • Database on plants of European Russia • Integrated software systems for vegetation assessment and analysis • Assessment and prognosis of biodiversity • Statistical modeling of phytocenosis Population-demographic models • Functional groups of plants for European Russian forests • Modeling of forest ground vegetation diversity • Decision Support Systems for Forest Management Now in the laboratory the following databases are developed and active supported: Flora of vascular plants of European Russia (information on ca. 2600 species). • Online database on finds of rare lichen species *Lobaria pulmonaria* in Russia (about 500 records). • Database on geobotanical relevés • Database on biomass of plant species in ground vegetation

Endorsed by: [Participant Node Managers Committee](#)

Installations: [Russian GBIF IPT](#)

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Global Index of Vegetation-Plot Databases



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EU-RU-014 - Temperate Forests of European Russia <http://www.givd.info/ID/EU-RU-014> Khanina, Larisa et al. 5073 plots [Back to list](#)

Description

Contact Information

Statistics

Formations

Additional data

Database Details

Please refer to the ID **EU-RU-014** whenever using data from this particular database

ID:	EU-RU-014
Registered since:	2018-03-13
Last update:	2018-03-16
Web address	
Fact Sheet	Download
Availability: (fact sheet)	according to a specific agreement
Name of the Database:	Temperate Forests of European Russia (required field)

Name of the Database: **Temperate Forests of European Russia** (required field)

Subtitle: (fact sheet) Module of the FORUS database

Editor of GIVD Database Entry

Editor: Larisa Khanina

Scope

(fact sheet)

Database includes about 5000 vegetation relevés sampled mostly in State nature reserves and National parks of European Russia (mainly Moscow, Kaluga, Voronezh regions; the Chuvash and Mari El republics). Vascular floristic plots with cover abundance recording in forest and meadow communities are entered including plots on abandoned agricultural lands.

Details

Status: (fact sheet) completed and continuing

Storage Format/Programm: (fact sheet) Export Format: (fact sheet)

Plant functional groups for carbon and nitrogen cycle modelling and diversity estimation

Ground vegetation layer = field layer
(herbs, grasses, dwarf shrubs, etc.) +
bottom layer (mosses, lichens)



Ecological-coenotic groups (ECG) of plants

Nemoral – species of broad-leaved forests

The ECG list is accessible by

<http://www.impb.ru/index.php?id=dv/lce/ecg&lang=eng>



Boreal – species of dark-coniferous forests



Piny – species of pure *Pinus sylvestris* forests



Meadow-edge species



Nitrophilous – species of *Alnus glutinosa* forests

Species of **oligotrophic** bogs



Water-marsh species

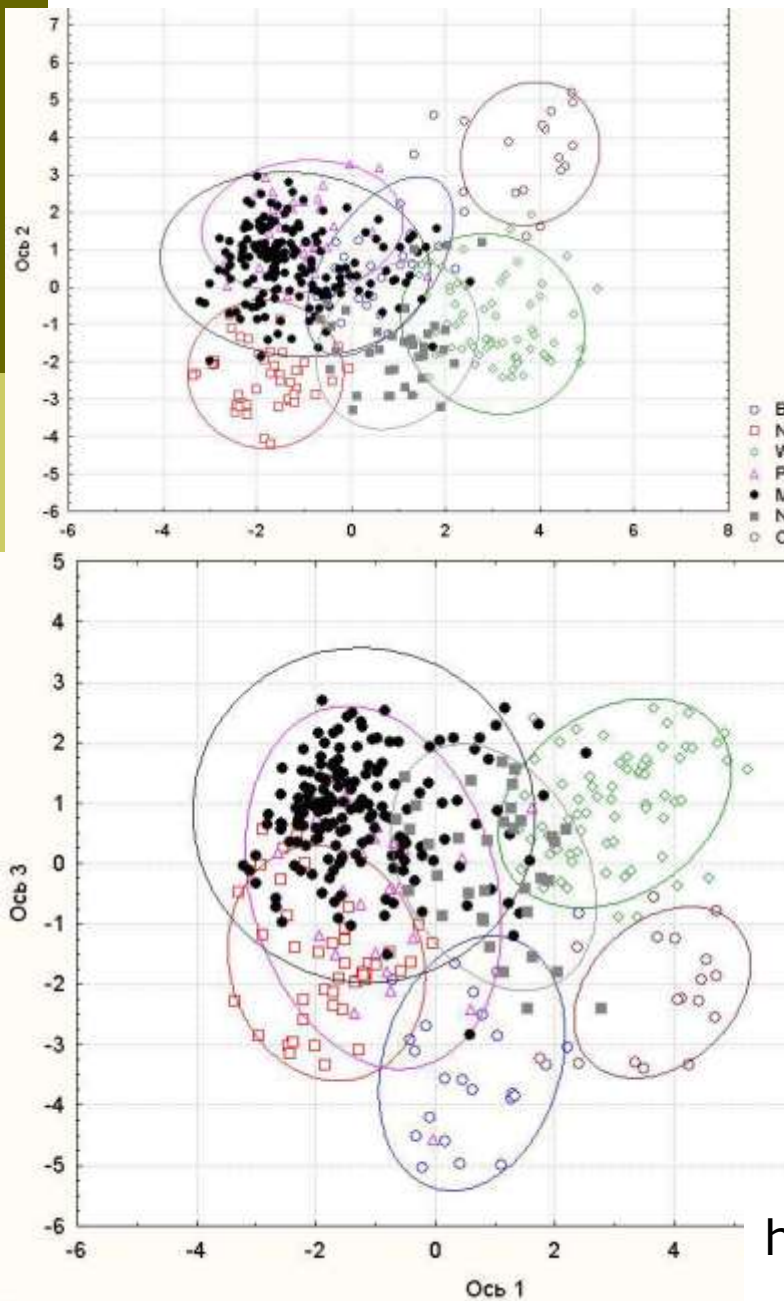


Only 7 main groups with ab.
10 subgroups

The composition of the ECG

(1) defined by experts (Nitcenko, 1968, Smirnova & Zaugolnova, 2001, Smirnova et al., 2004), and
(2) verified by discriminate analysis and decision tree techniques (Smirnov et al., 2006) using

- **Ellenberg's indicator values** (1991) and
- **species ordination scores** produced by NMDS of more than **3000 phytosociological relevés** from European Russian forests




<http://www.impb.ru/index.php?id=div/lce/ecg>

Browser tabs: Inbox - khanina, Information tech, IPT, https://www.gi, European Russi, Model Predictic, Institute of Mat

Address bar: Не защищено | www.impb.ru/index.php?id=div/ice/ecg&lang=eng

File module overview, Новая вкладка, RGB Chart & Multi T, Context переводчик, Планы генеральног



РАН
ИМПБ

Russian Academy of Sciences
Institute of Mathematical Problems of Biology
Russian

Structure

Validation of the ecological-coenotic groups of vascular plants for European Russian forests on the basis of ecological indicator values, vegetation releves and statistical analysis (2008)
V.E. Smirnov, L.G. Khanina, M.V. Bobrovsky

The original approach for finding, testing and analysis of ecological-coenotic plant species groups (ECG) is proposed (Smirnov et al., 2005a,b, 2006a,b). The approach has been tested on the ECG system for the vascular plants of European Russian forests developed earlier by O.Smirnova and L.Zaugolnova with contribution of O.Evstigneev and T.Braslavskaya. The ECG system is an extension of Nitscenko ECG system (1969) and Zozulin historical suites (1970, 1973). The groups were obtained on the base of expert knowledge, and thus their verification by formal methods was desirable step. Ecological and coenotic species features for quantitative analysis were presented as variables of two types: (1) Ellenberg indicator values and (2) species scores derived from ordination of vegetation plots. The ordination was conducted by non-metric multidimensional scaling (NMS) technique and ordination scores for the species were calculated by weighted averaging of the plots coordinates. Further, discriminant analysis and decision trees analysis were used to identify misclassified species in ECG. The procedure was run repeatedly on the whole set of variables and on various subsets of them, with monitoring of results by experts on every step of the analysis. This continued until a position of species in the ECG system fits both statistical results and expert judgment. Such joint expert-statistical approach allowed to greatly improve the ECG system, to put more than 1000 vascular species into the groups and to outline core species and intermediate species.

The presented here ECG system includes the basic seven groups and regional groups for boreal (northern and middle taiga), hemiboreal and temperate forest zones of European Russia. The regional groups were calculated for all species registered in the [regional sample plots data](#).

This work was supported by RFBR projects 01-04-49098 (team-leader is Prof. Smirnova, Olga) and [05-04-49289](#) (team-leader is Dr. Khanina, Larisa).

Legends:

Aa	tundra-arctic group;
Br	boreal group (species of spruce and spruce-fir boreal forests)
Br_k	boreal dwarf-shrubs and evergreen herbs group
Br_s	boreal dwarf-shrubs and evergreen herbs group

1165 vascular plant species were divided into 7 main groups

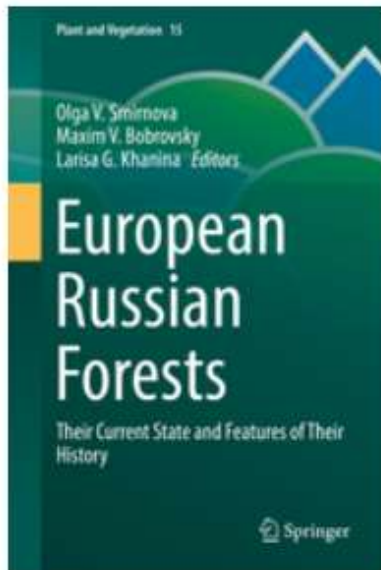
Typical species of the ECGs

1. the **boreal** group (Br) *Vaccinium myrtillus*, *Linnaea borealis*, *Lycopodium annotinum*, *Gymnocarpium dryopteris*, *Luzula pilosa*, *Maianthemum bifolium*, *Oxalis acetosella*,
2. the **nemoral** group (Nm) *Aegopodium podagraria*, *Asarum europaeum*, *Convallaria majalis*, *Dryopteris cartusiana*, *Lathyrus vernus*, *Melica nutans*, *Milium effusum*, *Pulmonaria obscura*;
3. the **nitrophilous** group (Nt) *Filipendula ulmaria*, *Thalictrum minus*, *Trollius europaeus*, *Veratrum lobelianum*, *Veronica longifolia*;
4. the **piny** group (Pn) *Antennaria dioica*, *Vaccinium vitis idaea*, *Arctostaphylos uva-ursi*, *Calluna vulgaris*, *Veronica officinalis*;
5. the **meadow-edge** group (Md) *Dactylis glomerata* *Dianthus superbus*, *Elytrigia repens*, *Festuca ovina*, *Pulsatilla patens*, *Thymus serpyllum*, *Lathyrus pratensis*, *Knautia arvensis*;
6. the **water-marsh** group (Wt) *Caltha palustris*, *Carex vesicaria*, *Equisetum fluviatile*, *C.elongata*, *C.cespitosa*;
7. the **oligotrophic** group (Olg) *Carex globularis*, *Eriophorum vaginatum*, *Ledum palustre*, *Oxycoccus palustre*, *Vaccinium uliginosum*

Ecological-coenotic groups (ECGs) of plants

» Life Sciences » Forestry

Plant and Vegetation



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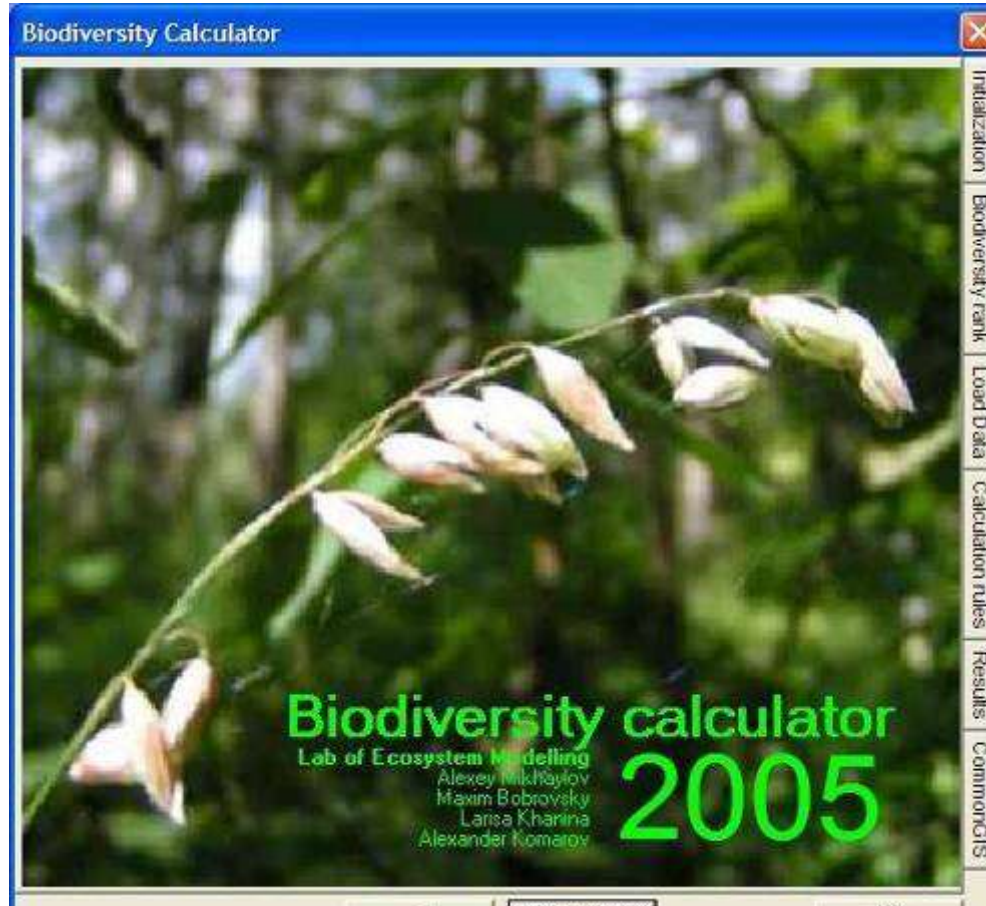
European Russian Forests

Their Current State and Features of Their History

Editors: **Smirnova**, Olga V., **Bobrovsky**, Maxim V., **Khanina**, Larisa G. (Eds.)

ECGs were used in forest typology and in estimation of structural diversity of vegetation

BioCalc - software to calculate dynamics of ground vegetation diversity. Applied with the models EFIMOD, ROMUL, FORRUS

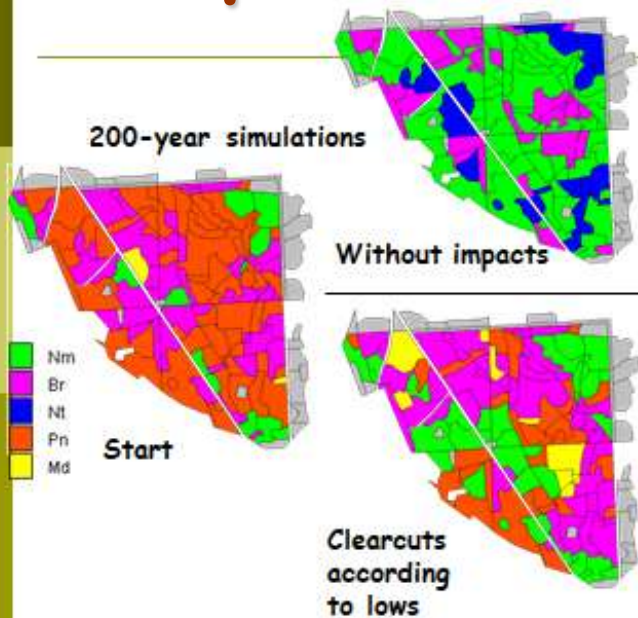


Seven ECG were used to modelling dynamics of species richness and structural diversity of ground layer of forest vegetation under 4 forest management regimes and 2 climate change scenarios

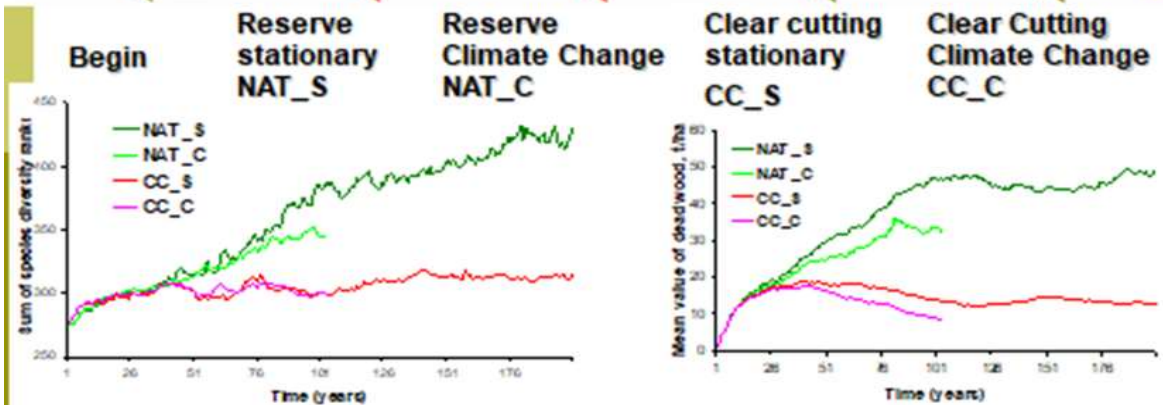
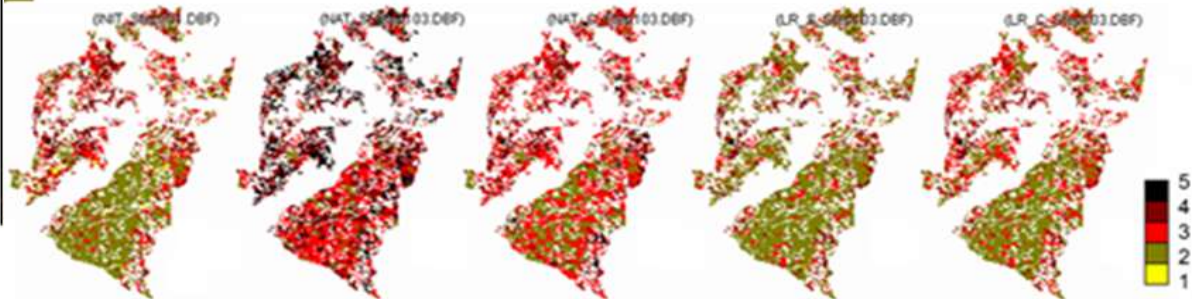
Khanina et al., For. Ecol. Manage. 2007: 80-94

Khanina et al., 2014. Nitrogen Deposition, Critical Loads and Biodiversity: 173-182

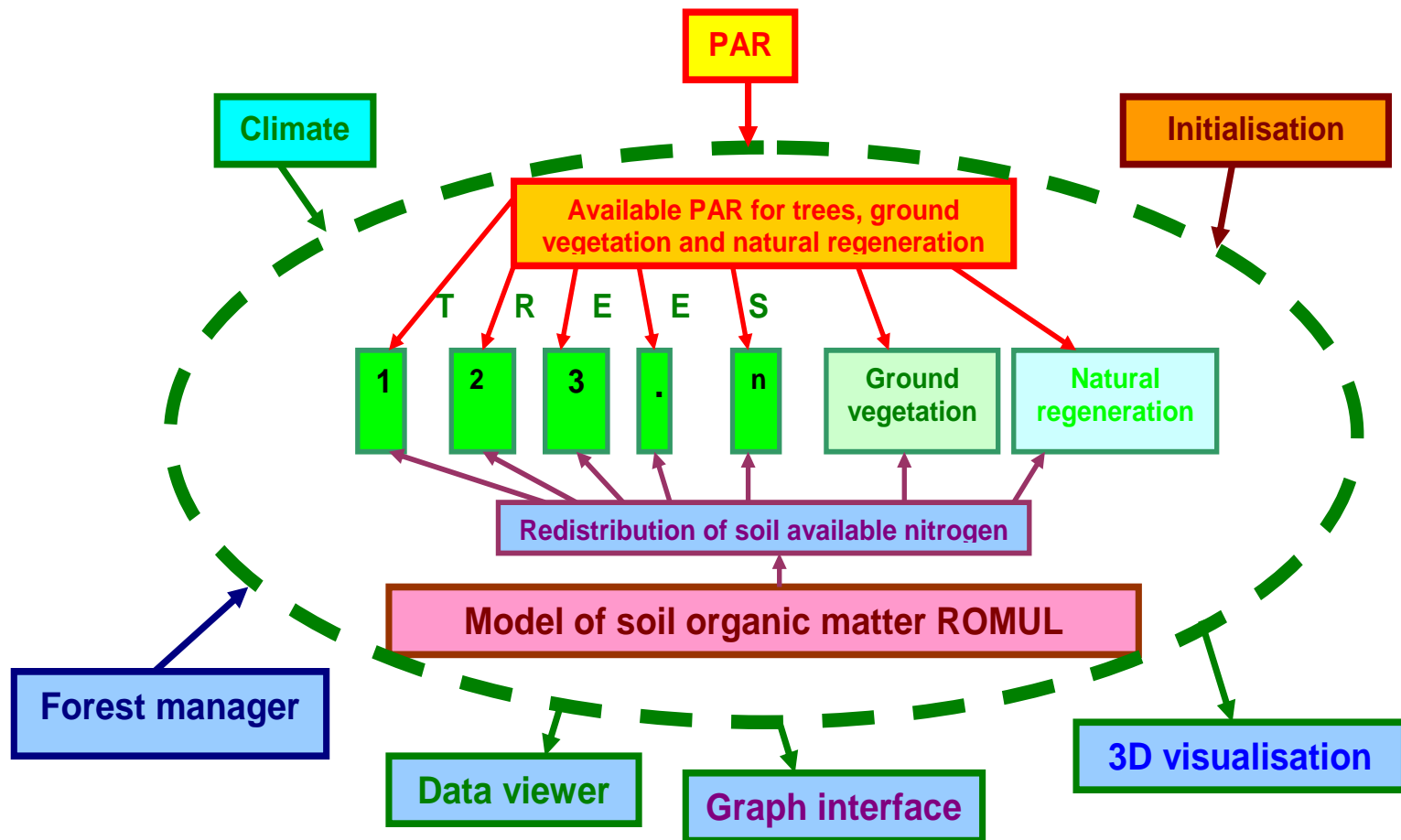
Examples of the simulated ECG dynamics and plant diversity assessment



Plant diversity dynamics under climate-change scenarios



Plant functional groups for carbon and nitrogen cycle modelling in forest ecosystems



in a frame of the EFIMOD model
(Komarov et al., 2003 and many others)

Functional groups in forest ground vegetation for the cycles modelling

Combination of Ecological-Coenotic Groups and Life Form Plant Traits:

- Lichens
- Mosses
- Herbs which fall in the end of vegetative season
 - Small herbs and small ferns
 - Tall herbs and large ferns
 - Grasses
- Evergreen herbs separated along to fall regime
- Deciduous dwarf shrubs
- Evergreen dwarf shrubs

Functional groups in forest ground vegetation for the cycles modelling

Combination of Ecological-Coenotic Groups and Life Form Plant Traits

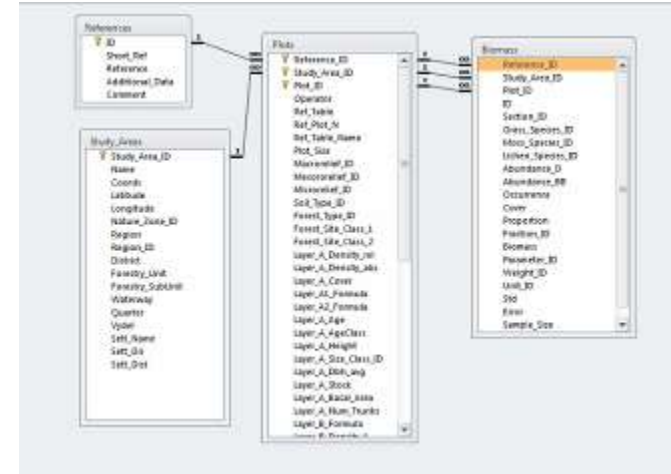
- **Biomass and productivity of plant species**
- **Chemical composition**
- Rate of decomposition
- Nutrient, water and light species' supplies

Databases

biomass of species and groups of species
chemical composition of plants

BIOMASS - a database on forest ground vegetation's biomass


Data sources - 79 scientific publications and original field data. More than 7000 records. 231 species. 103 study areas.



28 tables: 7 main frames,
18 reference tables, 3 flora lists

Главная кнопочная форма

Живой напочвенный покров



☐

Работать с источниками

☐

Работать с местами исследований

☐

Работать с биомассой

☐

Завершить работу

Версия: 0.1

Дата: 09.04.2012

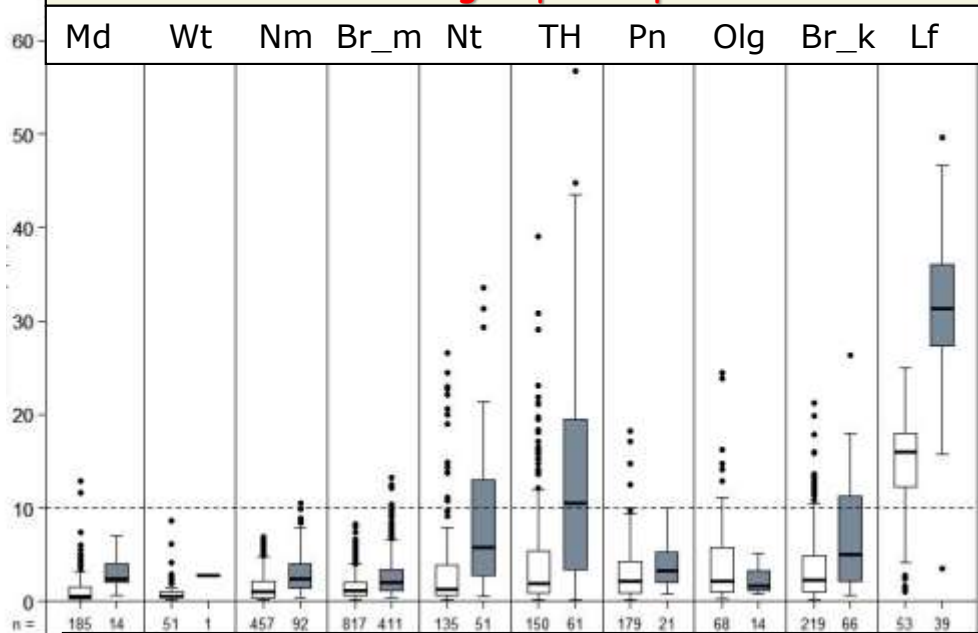
Пояснение, в каком порядке наводить базу.

1. Сначала добавлять новый литературный источник: открыть форму "References", добавить источник, закрыть форму.
2. Добавить новое место исследования: открыть форму "Study Areas", добавить новое место (не забыть присвоить ему имя), закрыть форму.
3. Создать новую площадку: открыть форму "Plots", создать новую запись, в поле "Источник" выбрать источник, в поле "Место исследования" выбрать нужное место исследования, в поле "№ площадки" ввести не занятый номер (нумерация начинается каждый раз с единицы).
4. Вести общую информацию о площадке. Во вкладке "Измерения" вводить информацию о навозе.

[illegible]

Functional groups of species

Biomass, $(g/m^2)^{1/2}$

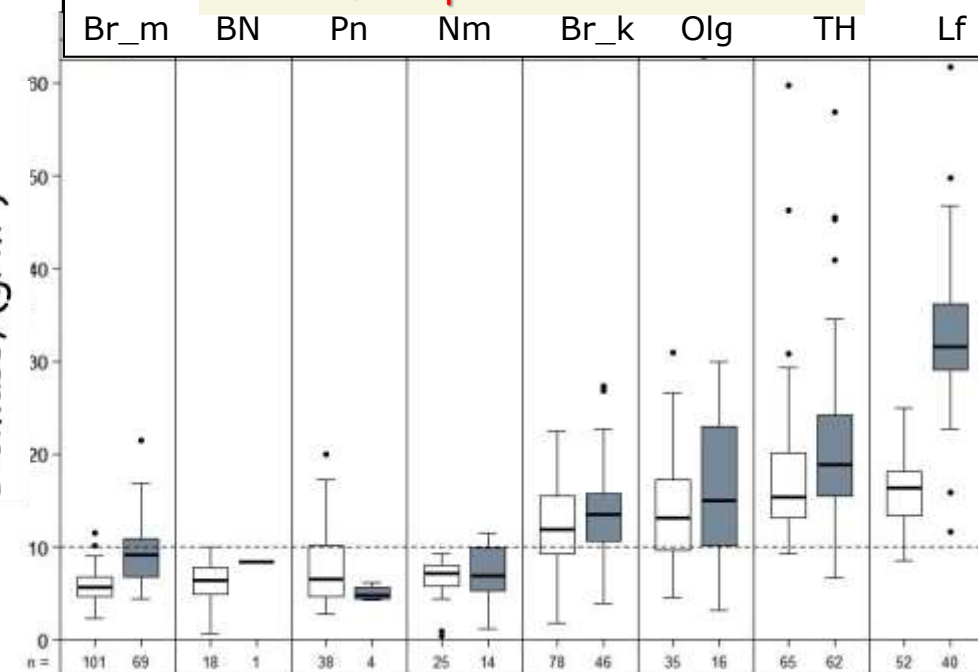


Forest floor patches were marked by the domination of FG in the plots

- Forest floor patches dominated by FG were better differed by the biomass values of vascular plants than by FGs

Forest floor patches

Biomass, $(g/m^2)^{1/2}$



- Below-ground biomass was higher than above-ground biomass

- FGs and patches were better differed by below-ground values

Comparison of literature and experimental (field) data on plant biomass



Uneven-aged forests dominated by *Picea abies* and *Abies sibirica* with *Tilia cordata* in the hemiboreal forest region.

Kostroma administrative region (Irina Grozovskaya's data)



Forest types investigated

1. Spruce-fir forest dominated by small boreal herbs, *V. myrtilus* and large ferns
2. Spruce-fir forest dominated by herbs
3. Spruce forest dominated by *V. myrtilus*
4. Spruce-lime forest dominated by large ferns
5. Spruce forest dominated by small boreal herbs
6. Spruce forest dominated by tall boreal herbs

40x40 m plots in 3 replications in each forest type

6

1

5

4

2

3

Small boreal herbs & ferns (Br)



Forest floor
patches
25x25 cm,
in 3 replications.
Totally 45 plots

Large ferns (Lf)



Boreal-nemoral plants (BN)



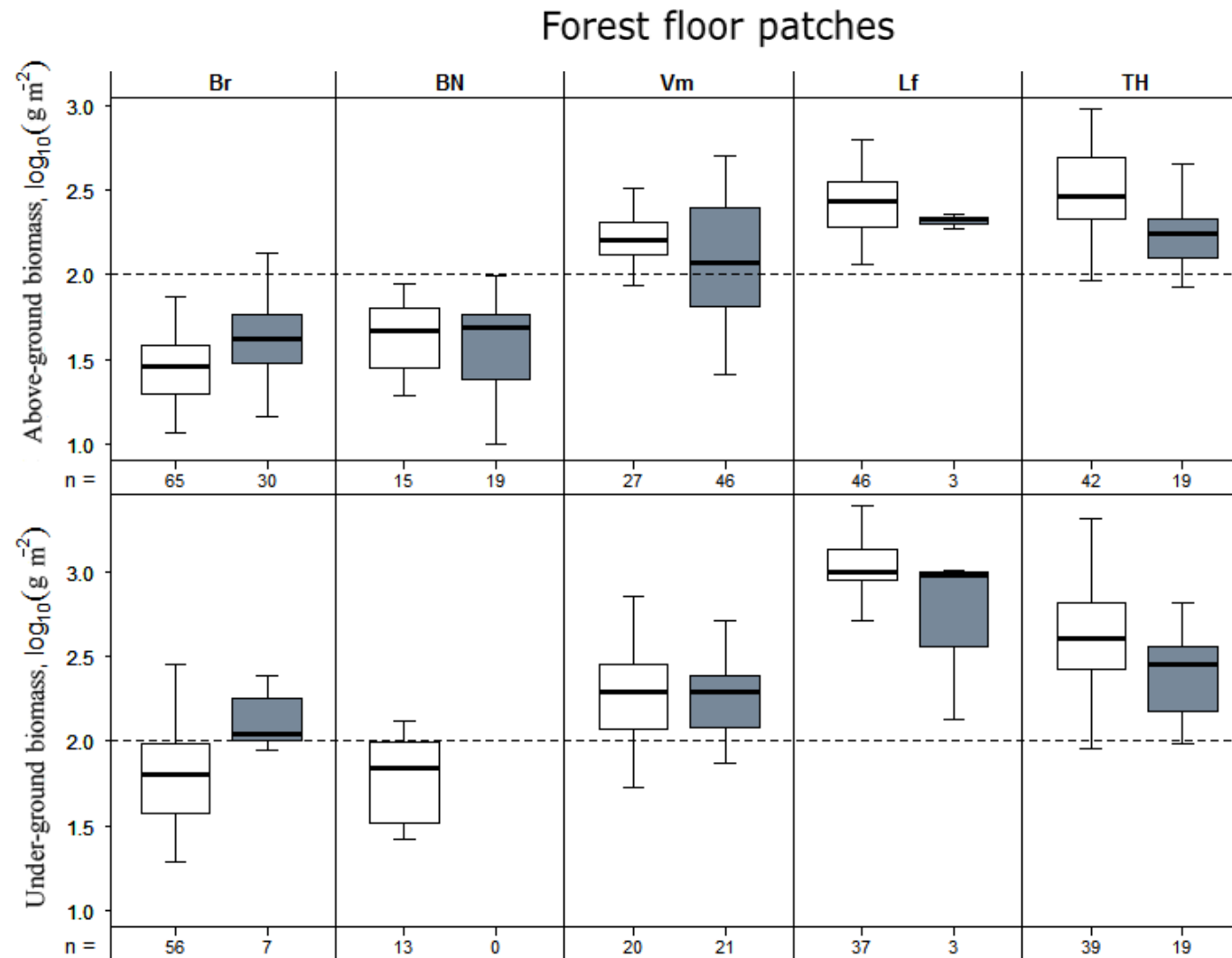
Tall boreal herbs (TH)



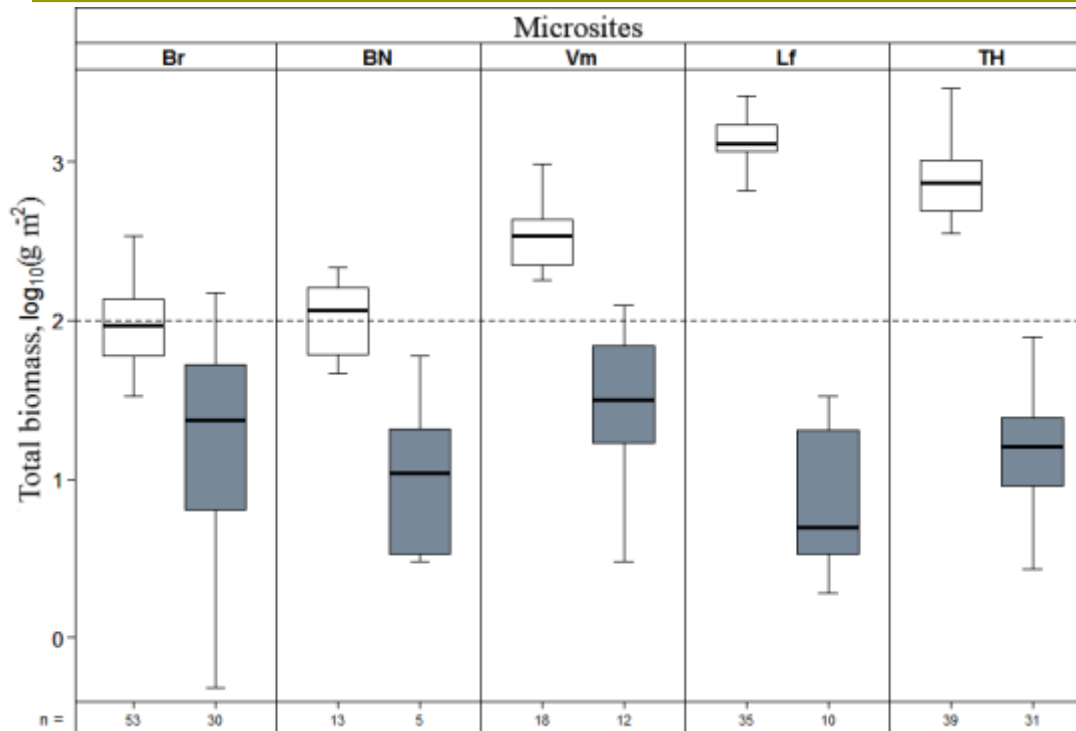
Boreal dwarf-shrubs (Vm)



Above- and below-ground biomass of vascular plants along to experimental (white) and literature (grey) data



Experimental data on forest floor patches: total biomass of vascular plants (white) and mosses (grey)



A forest type and a forest floor patch were significant factors, but the input of the forest floor patch was the highest

Forest floor patches dominated by species of different FG turned out to be the best factors differing the biomass of ground layer vegetation

Three-way nested ANOVA

Source of var.	Above-ground		Below-ground	
	VC, %	P	VC, %	P
Forest type	30.0	0.001	17.3	0.004
Floor patch	60.7	0.000	70.5	0.000
Error	9.3		12.2	

ELEMENTS - a database on plant species chemical composition

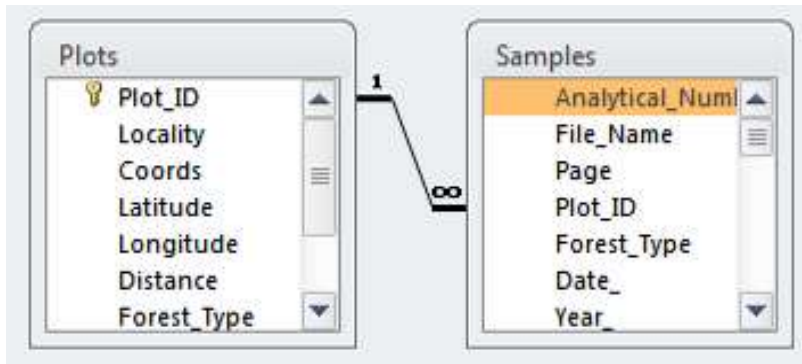
The screenshot shows a software window titled 'ELEMENTS'. It has a menu bar with 'Файл', 'Правка', 'Вид', 'Сервис', 'Справка'. Below the menu is a toolbar. The main area is a data entry form for a plant sample. It includes fields for 'Семейство' (Family), 'Род' (Genus), 'Вид' (Species), 'Пол' (Sex), 'Возраст' (Age), 'Высота' (Height), 'Диаметр' (Diameter), 'Площадь' (Area), 'Вес' (Weight), 'Дата' (Date), 'Локация' (Location), 'Координаты' (Coordinates), 'Дистанция' (Distance), 'Тип леса' (Forest Type), 'Плотность' (Density), 'Влажность' (Moisture), 'Температура' (Temperature), 'Давление' (Pressure), 'Ветер' (Wind), 'Облачность' (Cloudiness), 'Солнечная радиация' (Solar radiation), 'Температура почвы' (Soil temperature), 'Влажность почвы' (Soil moisture), 'pH почвы' (Soil pH), 'Содержание элементов' (Element content). The 'Содержание элементов' section is expanded, showing a table with columns for elements (C, H, N, P, K, Ca, Mg, Na, Al, Fe, Mn, Zn, Ni, Cu, S, Zn) and their content in mg/kg. The table has 15 rows and 16 columns. The first row is for 'C' (Carbon) with a value of 45.00. The second row is for 'H' (Hydrogen) with a value of 6.00. The third row is for 'N' (Nitrogen) with a value of 1.00. The fourth row is for 'P' (Phosphorus) with a value of 0.10. The fifth row is for 'K' (Potassium) with a value of 0.50. The sixth row is for 'Ca' (Calcium) with a value of 0.10. The seventh row is for 'Mg' (Magnesium) with a value of 0.10. The eighth row is for 'Na' (Sodium) with a value of 0.10. The ninth row is for 'Al' (Aluminum) with a value of 0.10. The tenth row is for 'Fe' (Iron) with a value of 0.10. The eleventh row is for 'Mn' (Manganese) with a value of 0.10. The twelfth row is for 'Zn' (Zinc) with a value of 0.10. The thirteenth row is for 'Ni' (Nickel) with a value of 0.10. The fourteenth row is for 'Cu' (Copper) with a value of 0.10. The fifteenth row is for 'S' (Sulfur) with a value of 0.10. The sixteenth row is for 'Zn' (Zinc) with a value of 0.10.

Original data from Center for Forest Ecology and Productivity of RAS & Institute of Applied Ecological Problems in the North of Kola SC of RAS

More than 2500 samples, 80 species

N, C, Ca, Mg, Na, K, Al, Fe, Mn, Zn, Ni, Cu, P, S, Zn

Northern and middle taiga area, boreal forest region



- Place and time of sampling
- Species and its fractions
- Chemical composition, mg/kg

Polluted area mainly

We selected **542 samples, 68 species** (or group of species) from "the clean areas"

Cu, Ni < 5 mg/kg

Species Functional Groups analyzed by the ELEMENTS database (boreal forest region)

1) Lichens

2) Mosses

3) Small boreal herbs

Equisetum sylvaticum, *Gymnocarpium dryopteris*, *Maianthemum bifolium*, *Oxalis acetosella*, *Phegopteris connectilis*, *Rubus saxatilis*, *Trientalis europaea*

4) Tall boreal herbs

Aconitum septentrionale, *Athyrium filix-femina*, *Cacalia hastata*, *Chamaenerion angustifolium*, *Crepis sibirica*, *Diplazium sibiricum*, *Dryopteris carthusiana*, *D.dilatata*, *Geranium sylvaticum*, *Paeonia anomala*, *Rubus idaeus*

5) Boreal grasses (*Avenella flexuosa*)

6) Boreal dwarf shrubs (deciduous dwarf shrubs and ever-green herbs)

Vaccinium myrtillus, *Lycopodium* sp.

7) Piny dwarf-shrubs (evergreen dwarf-shrubs) *V.vitis-idaea*

8) Nitrophilous large herbs *Cirsium oleraceum*, *Filipendula ulmaria*

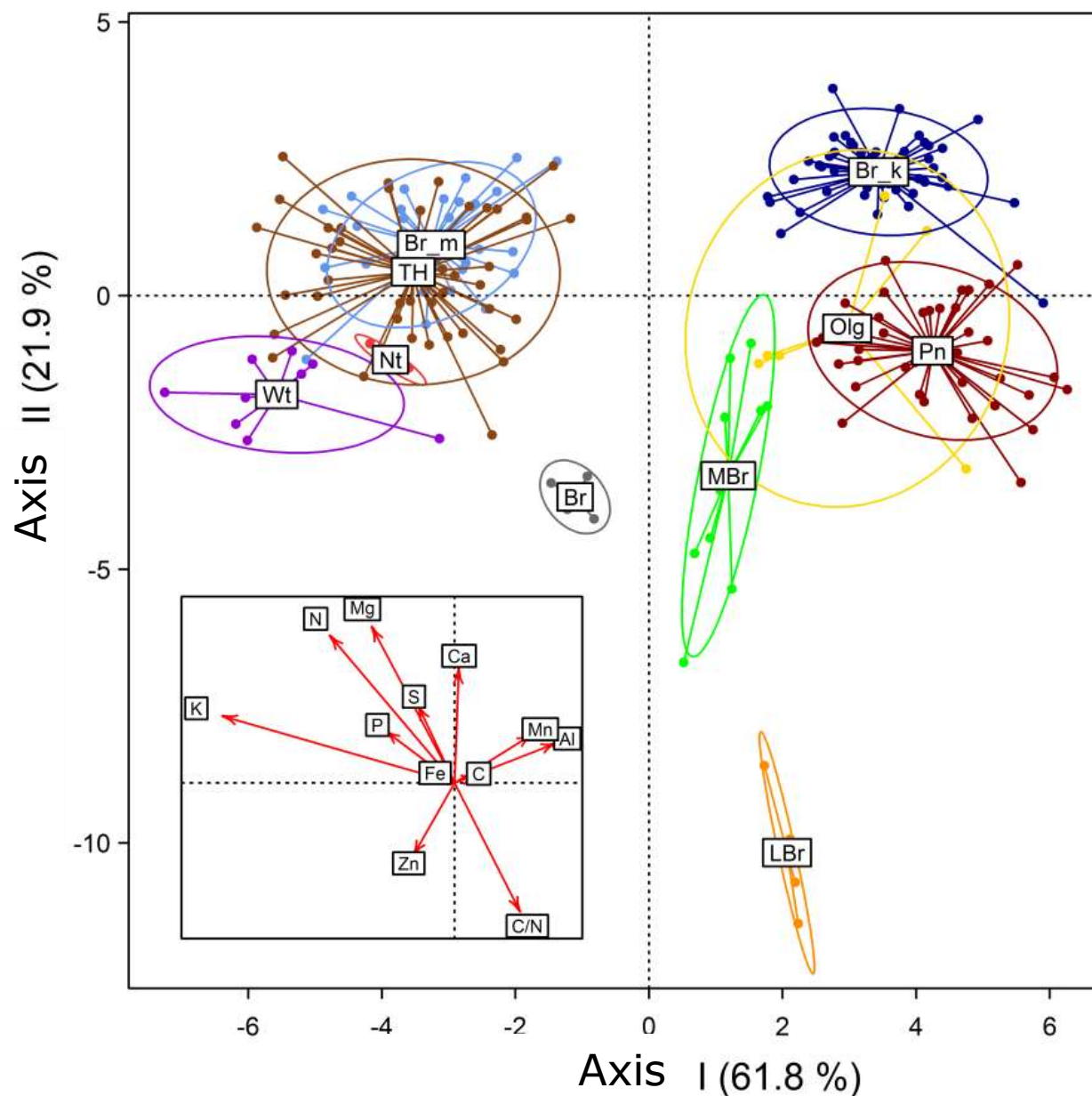
9) Oligotrophic ever-green and deciduous dwarf-shrubs

Empetrum hermaphroditum, *Ledum palustre*, *V.uliginosum*

10) Water-marsh plants

Calamagrostis phragmitoides, *Eleocharis* sp., *Phragmites* sp., *Scirpus* sp.

11) Intra-water plants



**Linear
Discriminant
Analysis of 204
records from
the ELEMENTS
database.
39 species,
10 FG**

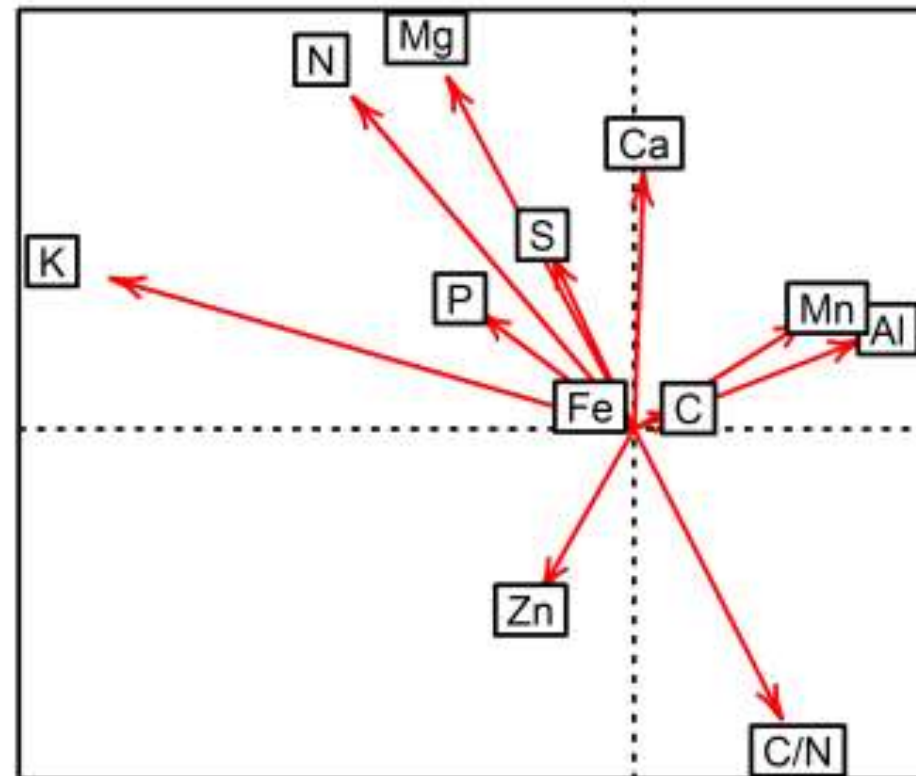
Wt - water-marsh species,
Nt - nitrophilous species,
TH - tall boreal herbs,
Br_m - small boreal herbs,
Br - *Avenella flexuosa*,
MBr - boreal mosses,
Br_k - boreal dwarf-shrubs,
Olg and Pn - oligotrophic and
piny dwarf-shrubs,
LBr - boreal lichens

More than 88% of the objects were well classified.
First two axes explained ab.84% of the intergroup dispersion

Std. canonical coeff. for two first can.variations

	Can.Var. 1	Can.Var. 2
C/N	1.84	5.08
N	1.79	3.46
K	-1.30	0.07
C	-0.95	-2.69
Mn	-0.01	-0.72
Al	0.91	-0.27
Ca	0.52	-0.42
Fe	-0.56	0.33
P	0.51	0.05
S	0.08	-0.17
Zn	-0.21	0.34

Factor loads



Analysis of BIOMASS & ELEMENTS databases

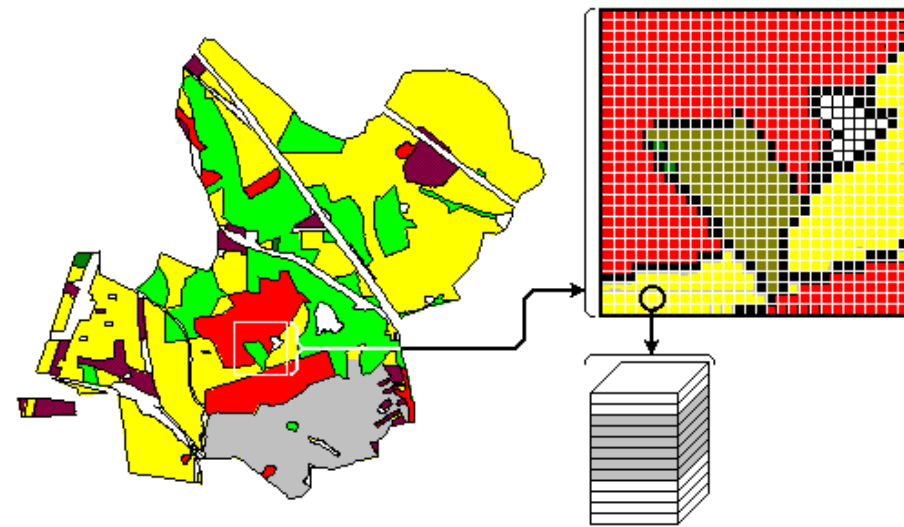
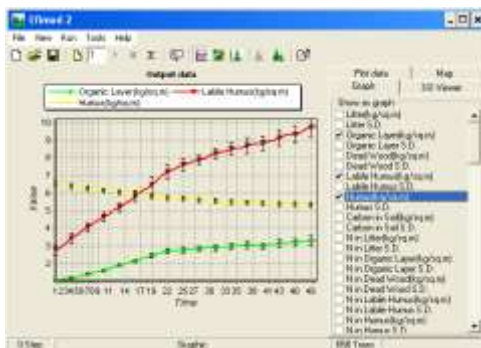
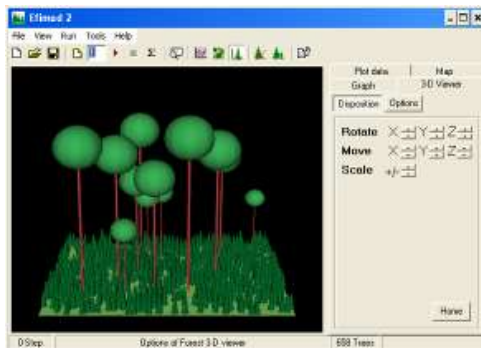
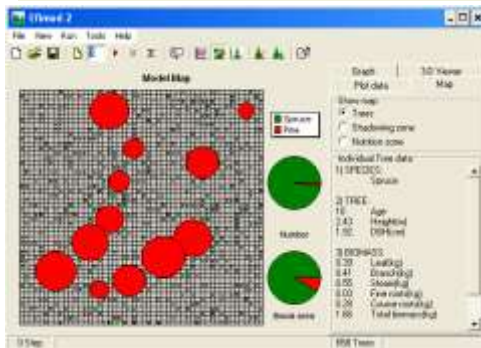
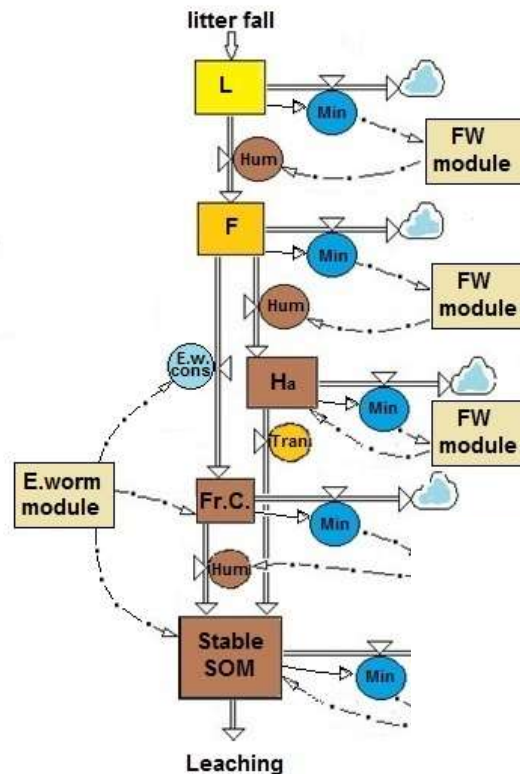
- Forest floor patches dominated by the proposed FG are well differed by the biomass values
- Species belonging to the one FG have similar values on the content of the main chemical elements
- The patterns allow the developing the approach to simulate ground vegetation dynamics by the changing proportions of different patches contributed to the biogeochemical cycle in forest ecosystems

System of models: Romul (soil) + EFIMOD (trees)

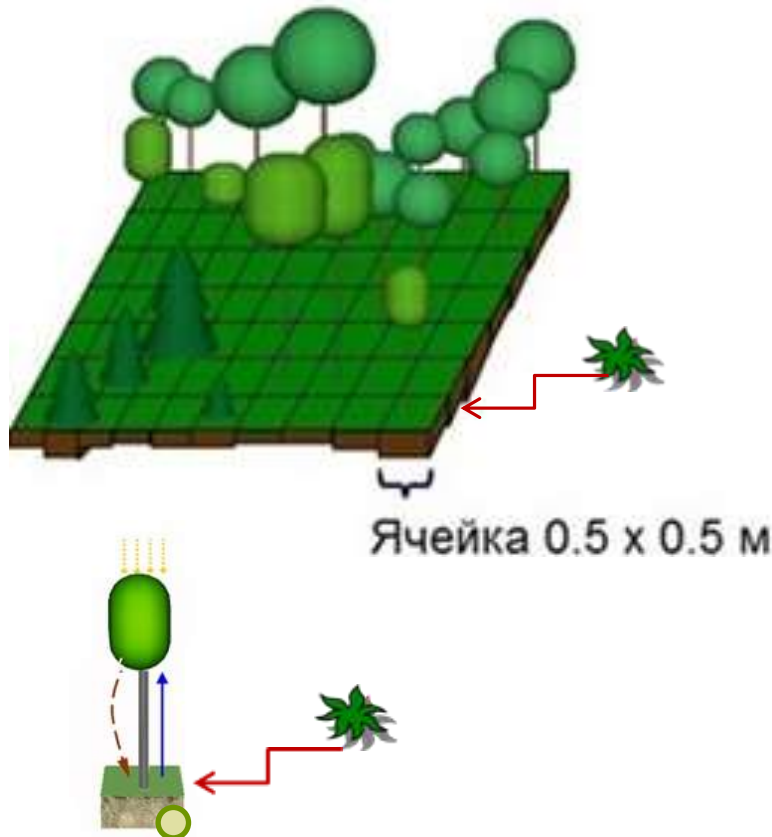
or
Romul-HUM
(Chertov et al.,
2017: Romul +
SoilFoodWeb &
E.worm) +

FORRUS
(Chumachenko et
al., 2003)

One cohort of aboveground litter fall



Dynamics of forest ground vegetation



In the EFIMOD model, a cell for tree modelling is 0.5×0.5 m

Spatial unit for ground vegetation modelling is a forest floor patch dominated by one or two FG

Forest floor patch in the model is proposed to be of the same size 0.5×0.5 m

Parameters of the EFIMOD+ROMUL unit is changing at each simulated step (1 year) and ground vegetation will be also changed with feedback to ROMUL and then to EFIMOD

Conclusion

- We have proposed a system of Functional Groups of plant species from ground layer of forest vegetation for modelling nutrient and carbon cycles in forest ecosystems
- Forest patch dominated by FG of plants are well differed in their biomass values
- Species belonging to a particular FG had similar values on the content of the main chemical elements
- We have proposed a conceptual model for ground vegetation dynamics which will be realized in a system of soil-forest biogeochemical cycle models (ROMUL - EFIMOD or Romul-HUM - FORRUS)

Development and analysis of the database “Elements” was supported by the Russian Science Foundation, project №16-17-10284

The results were received under the POLYFORES project:
Decision-making Support for Forest Ecosystem Services in Europe - Value Assessment, Synergy Effects and Trade-offs (FP7 ERA-NET Sumforest)



THANK YOU VERY MUCH FOR YOUR ATTENTION!

